Bits & Bytes: Level I – ANSWER KEY

* Important Information:

- 1 byte = 8 bits.
- 1 kilobyte (KB) = 1,024 bytes.
- 1 megabyte (MB) = 1,024 kilobytes.
- 1 gigabyte (GB) = 1,024 megabytes.
- 1 terabyte (TB) = 1,024 gigabytes.
- Here, assume that every character takes up 1 byte of storage space.
- Here, assume that a floppy disk has a capacity of 1,474,560 bytes.
- Here, assume that a CD has a capacity of EXACTLY 700 megabytes.

How Many X are in a Y?

1) [1 point] 23 kilobytes = 23,552 bytes.
2) [1 point] 14 megabytes = 14,680,064 bytes.
3) [1 point] 3.75 gigabytes = 3,840 megabytes.
4) [1 point] 4,096 kilobytes = 4 megabytes.
5) [1 point] 3,584 bytes = 3.5 kilobytes.
6) [1½ points] One CD can store as much data as about 498 floppies. Round to the nearest floppy.
7) [1½ points] A 2-terabyte hard drive can store as much data as about 2,996 CD's. Round to the nearest CD. Assume that the hard drive can store EXACTLY 2 TB of data.

8) [3 points] You have 18.5 gigabytes of data to back up.
   a. [1½ points] If you want to use recordable CD's to back up your data, how many of them will you need to complete the backup? Your answer must be a whole number.

      28 CD's

   b. [1½ points] If you had to use floppies to back up your data, how many of them would you need to complete the backup? Your answer must be a whole number.

      13,472 floppies

* You can see why we don't use floppies to back up our data any more! :-)

9) [1½ points] The files you needed to install the computer game, Paxicom[†], on your computer required 9 megabytes of storage space. If this game came on a set of floppy disks, how many floppies did ZeboSoft[‡] (the game's publisher) need to store Paxicom's installation files? Your answer must be a whole number.

   7 floppies

[†] Not the name of a real computer game, as far as I know.
[‡] Not the name of a real software publisher, as far as I know.

10) [2 points] Fill in the missing exponents:
   a. [½ point] 1 kilobyte = 2^{10} bytes.
   b. [½ point] 1 megabyte = 2^{20} bytes.
   c. [½ point] 1 gigabyte = 2^{30} bytes.
   d. [½ point] 1 terabyte = 2^{40} bytes.

* Do you see a pattern here? ;-)

How Many Bytes Does it Take to Store …

11) [1 point] How many bytes does it take to store the following text *string*?

    `happy`

    5 bytes

12) [2 points] How many bytes does it take to store the following text string?

```
Hello! How are you doing today?
```

Note: Each word is separated from the others by ONE space.

31 bytes

13) [3 points] How many bytes does it take to store the following 3-line text string?

```
ATTENTION All Users:
The network is going down in 15 minutes for maintenance!
Save your work, and log off AS SOON AS POSSIBLE!!!
```

* Notes:

- Each word on each of the 3 lines is separated from the others by ONE space.
- Each line is separated from the others by ONE *newline*.

a. [1½ points] On a Windows system, a newline consists of TWO characters: a *carriage return* and a *line feed*. How many bytes does it take to store the above message on a Windows system?

130 bytes

b. [1½ points] On a UNIX system, a newline consists of ONE character: a line feed. How many bytes does it take to store the above message on a UNIX system?

128 bytes

14) [5 points] This question delves into the topic of how images are stored on a computer. The PIX *file format* discussed below is not a "real" image file format. However, it is useful in understanding "real" file formats that are used to store *uncompressed* digital images, such as the BMP file format.

- A PIX file starts with a *header*, which contains the following data about the image:
  - A 3-byte code that identifies the file as a PIX image file.
  - A 1-byte code that indicates how colors are stored in the image.
  - A 4-byte number: the image's width (in *pixels*). Call this number "**W**".
  - Another 4-byte number: the image's height (in pixels). Call this number "**H**".

a. [1 point] How many bytes does it take to store the header of a PIX file?

12 bytes

- The above header is followed by the pixels that make up the "**W** × **H** image":
  - An image consists of **H** *rows* of pixels.
  - Each row of the image consists of **W** pixels.
  - A pixel can take up 1, 4, 8, 16, or 24 bits of space, depending on how colors are stored in the image. An image that uses **B** bits to store each of its pixels is called a "**B** *bits per pixel* (*bpp*) image".
  - NO extra bits get inserted between pixels.
  - NO extra bits get inserted between rows of pixels.
  - To store the image's pixels, you need at least **B** × **W** × **H** bits.
    - ➢ If **B** × **W** × **H** is evenly divisible by 8 (the number of bits in a byte), you don't need to add any extra bits after the image's pixels.
    - ➢ HOWEVER, if **B** × **W** × **H** is NOT evenly divisible by 8, you need to *pad* the last byte of the file with enough extra "0" bits to fill it up.

b. [3 points] How many bytes does it take to store the pixels of a 640 × 480, 8 bpp image?

307,200 bytes

c. [1 point] How many bytes does it take to store the whole PIX image file described in parts "a" and "b" of this question?

307,212 bytes

15) [3½ points] *Audio* (sound or music) can be stored on a computer as a bunch of numbers, just like every other kind of data! One way to record sound for storage on a computer is to have a program take a *sample* of the sound received by a microphone 44,100 times, every second. Each of these samples can be encoded as a 16-bit number. The audio file contains TWO *channels* of "sound": one channel that contains what should be heard by the listener's left ear and one that contains what should be heard by the listener's right ear.

   a. [2 points] How many bytes would a 3-minute song take up, if it was stored using the above file format? Assume that the audio file contains NO other data.

      ____31,752,000____ bytes

   b. [1½ points] If the above program only took 11,025 samples of sound every second, encoded each sample as an 8-bit number, and the audio file only contained ONE channel of "sound" (each of the listener's ears would hear the same sound: the sound in that one channel), the resulting audio file would be smaller by a factor of __16__.

How Long Does it Take to Download/Upload …

* Important Information:

- Internet/*download*/*upload* speeds are ALWAYS specified in "BITS [per second]" (*bps*), NOT bytes!
  - For example, "10 meg internet" = 10 megaBITS per second (*Mbps*)!
- 1 kilobit (Kb) = 1,024 bits.
- 1 megabit (Mb) = 1,024 kilobits.
- 1 gigabit (Gb) = 1,024 megabits.
- And, as always, 1 byte = 8 bits.

16) [1 point] You would like to download a game. The game's *installer* is 26.5 megabytes in size. If your internet [download] speed is 5 megabits per second, how long will it take you to download the game's installer? Round to the nearest second.

   __42__ seconds

17) [1 point] "Freddy the Frog" is about to upload a new video to his YouTube channel. If his upload speed is 10 megabits per second, how long will it take him to upload his 150-megabyte, *HD* video? Round to the nearest second.

   __2__ minutes and __0__ seconds

18) [2 points] Your luck has just taken a sharp turn for the worse! All of a sudden, your computer has decided to start downloading 3.75 GIGABYTES' worth of Windows updates! Unfortunately, this happened while the rest of your family was binge-watching Netflix! Since their *streaming* has eaten up NEARLY ALL of your household's *bandwidth*, your download speed has been reduced to an ABYSMAL 100 kilobits per second! At this rate, how long will it take you to download all of those Windows updates? Round to the nearest second. You love your family, but sometimes, ya kinda "hate" them, right?!

__87__ hours, __22__ minutes, and __53__ seconds

19) [1½ points] Back in the olden days, internet speeds were MUCH slower than they are today! When Elizabeth was getting her PhD, it took her 4 minutes and 16 seconds to upload her 300-kilobyte PhD thesis to her university's *bulletin board system* (*BBS*). How fast (bps) was the *modem* she used to upload her thesis? Round to the nearest whole bit per second.

__9,600__ bps

* Seriously, *dial-up* modems were once THAT slow!!!

20) [1½ points] Clumsy Carl lost the CD that came with his printer. Luckily, he could download the *drivers* (and other software) for his printer from the manufacturer's website. If the installer for his printer's software was 162.5 megabytes in size, and it took his computer 5 minutes and 47 seconds to download it, what was his average download speed, in megabits per second (Mbps)? Round to the nearest hundredth of a megabit per second.

__3.75__ Mbps